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FINAL

DELIVERY PERFORMANCE INDICATORS

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ARMY PROCUREMENT RESEARCH OFFICE

U.S. ARMY LOGISTICS MANAGEMENT CENTER
FORT LEE, VIRGINIA 23801

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DELIVERY PERFORMANCE INDICATORS

by

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Information and data contained in this document are based on input available at time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the US Army Materiel Development and Readiness Command unless so stated.

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EXECUTIVE SUMMARY

A. PROJECT BACKGROUND: Delivery of equipment in accordance with the user's required schedule is essential to DARCOM's materiel readiness mission. However, DARCOM is experiencing increasing problems with delinquent deliveries. For DARCOM's major subordinate activities, delinquent deliveries of items under contract have been as high as 34%. For DARCOM's major subordinate activities, procurement managers are often alerted of contractual delivery problems through analysis of data generated by performance indicators, such as delinquency rates. Since the current indicators often tend to look good in spite of continuing problems, it can be asked whether a revised indicator would better serve Army managers in becoming aware of problems so they may take corrective action.

B. OBJECTIVE: The objective of the study is to develop: (1) Contract Delivery Performance Indicators which will provide better information regarding the need for possible action to thwart an impending or actual delinquency; (2) Tentative numerical targets for Headquarters DARCOM and each of its major subordinate commands, using the performance indicator developed.

C. RESEARCH METHOD: The research methods utilized include: (1) a detailed examination of actual delivery data to discover the extent of the problem; (2) an analysis of the current indicators to see if they adequately measured contractor's performances; (3) development of a revised performance indicator to more accurately show the manager's success in achieving timely deliveries.

D. FINDINGS:

1. As currently defined, the performance indicator: (1) is easily computed; (2) gives the manager, particularly in supply management, useful data needed for maintaining supply status information. However, it tends to understate the delinquency problem. In certain situations, the indicator can look better even while the delinquency problem is getting worse.
2. The present performance indicator is not sensitive: (a) to the length of the delinquency (i.e., how far behind schedule) or (b) the criticality of the delinquency (the importance of the item to the Army, as opposed to the size of the contract).
3. As currently defined, the performance indicatpr rewards the practice of revising delivery schedules in the contractor's favor. While this study does not look at the extent to which this practice occurs, the potential for abuse is clear. It is also clear that as management attention increases, so does the pressure for abuse.

E. RECOMMENDATIONS:

1. Use the revised performance indicators, the Timely Delivery Index developed in this study, to measure timely deliveries.
2. Establish performance targets as developed in this study for HQ DARCOM and the MSC's.

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INTRODUCTION

A. PROJECT BACKGROUND

Delivery of equipment in accordance with the user's required delivery schedule is essential to DARCOM's materiel readiness mission. Performance indicators, such as contractual delinquency rates, are frequently used to measure an activity's success in obtaining timely deliveries. Such indicators also should provide information which alerts managers to the need for action when delinquent deliveries are prevalent.

B. PROBLEM

Delinquent contractual deliveries are a continuing problem, as evidenced by delinquent deliveries ranging up to 34% of the intensively managed items under contract.[1] These delinquencies result in: (1) delay or cancellation of vital missions; (2) decreased readiness of tactical units; (3) increased costs due to production schedule slippage and storage of partly assembled items. Further, if the government is not alerted to a problem soon enough, and thereby fails to take timely corrective action, the government may have constructively modified the contract and waived the delivery schedule.

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[1] AMCRP-SO Ltr of 24 Jun 75, Subj: An Analysis of Intensively Managed Items - Production Deliveries (April 1975).

Procurement has become more complex and some control techniques which may have served in the past need to be reviewed in items of modern challenges. In view of the high delinquency rates being experienced, a question can be raised regarding the value of the information being generated by the present delivery indicators. Also, a lack of performance standards and numerical targets make it difficult to evaluate an activity's success in meeting its objective of obtaining timely deliveries.

C. OBJECTIVES

1. Identify any shortcomings in the present performance indicators for timely deliveries.

2. If required, develop an improved performance indicator for timely deliveries.

3. Establish tentative numerical targets for HQ DARCOM and the MSC's.

D. SCOPE AND METHODOLOGY

1. Obtain actual delivery data for intensively managed items, to include the original schedule of required deliveries, the revised schedule, if any, and the history of deliveries made.

2. Analyze present performance indicators to determine if the information they give is timely, valuable, and accurate.

3. Revise present indicators and if necessary, develop new performance indicators.

4. Develop tentative numerical targets for HQ DARCOM and the MSC's based on the use of the recommended performance indicator for deliveries and on the historical delivery data.

CHAPTER II

ANALYSIS AND DEVELOPMENT OF PERFORMANCE INDICATORS

A. INTRODUCTION

Performance indicators for delinquency rates are frequently used to alert procurement managers of contract delivery problems. Thus, the first task was to determine if these performance indicators provided managers with pertinent, reliable and accurate information regarding contract deliveries.

B. CURRENTLY USED PERFORMANCE INDICATORS

The first performance indicator examined was:

$$\text{DELINQUENCY RATE} = \frac{\$ \text{ delinquent}}{\$ \text{ cumulative required delivery}}$$

One of the primary advantages of this indicator is its ease of computation. Additionally, it gives a manager a measurement of the percentage of item delinquent based on contract delivery schedules. Such information is useful to supply management activities in developing and maintaining supply status information. However, two major deficiencies were noted with this method. First, the delinquency rate is a function of previous deliveries. This point is illustrated by Table I below:

TABLE I

CURRENT DELINQUENCY RATE FUNCTION OF DELIVERIES PREVIOUSLY MADE

DELIVERIES \ CONTRACT PERIOD	1	2	3	4	5	6	7
REQUIRED	10	10	10	10	10	5	0
ACTUAL	0	10	9	9	9	8	10
CUMULATIVE REQ	10	20	30	40	50	55	55
DELINQUENT	10	10	11	12	13	10	0
DELINQUENCY RATE	100%	50%	37%	30%	26%	18%	0%

A comparison of actual versus required deliveries reveals that the cumulative number of delinquent units increases from 10 to 13 units as one progresses from period one to five respectively. However, the delinquency rate steadily decreases from 100% to 26% in the same time periods. Furthermore, even though 10 units are delinquent in both the second and sixth period, the delinquency rates are substantially different (50% versus 18% respectively). Thus, use of this indicator is giving management the misleading idea that the delivery situation is improving when, in fact, actual number of units delinquent is increasing.

The second problem with this method is that an individual contract's impact on the overall delinquency rate increases during the contract's life. This is illustrated in Table II below:

TABLE II

IMPACT ON DELINQUENCY RATE INCREASES DURING CONTRACT LIFE

	PERIOD I			PERIOD II		
	CONT. X	ALL OTHERS	TOTAL	CONT. X	ALL OTHERS	TOTAL
REQUIRED	100	200	300	200	200	400
DELINQUENT	5	40	45	10	40	50
DELINQUENCY RATE	5%	20%	15%	5%	20%	12.5%

As seen on the above table the following factors are kept constant for both periods: (1) dollar value of required and delinquent deliveries for all contracts (except contract X); (2) the delinquency rate of contract X. For contract X, dollar value of units required and delinquent are varied. Thus, the higher dollar value figures in period 2 for contract X indicates that it has progressed further in its life cycle. However, even though the delinquency rate is equal for both contract X and all other contracts in both periods, the aggregate delinquency rate is lower in period 2

(12.5 vs. 15%). Since contract X delinquency rate is lower than the rate for the other contracts, the greater impact of contract X on the delinquency rate, as it progresses through its life cycle, has resulted in a lower overall delinquency rate. Thus, management would again be given the false impression that the delivery situation was improving.

The second performance indicator was:

$$\text{Performance of Items Delinquent} = \frac{\text{Total Number Items Delinquent}}{\text{Total Number Items Under Contract}}$$

This technique is also lacking because it fails to reflect (1) lengths of the delinquency; (2) extent or dollar value of delinquency. Thus, two of the most commonly used indicators to measure success in obtaining timely deliveries were found to give managers misleading information. Hence, there is a need to develop a new performance indicator.

C. DEVELOPMENT OF A NEW PERFORMANCE INDICATOR

1. Introduction

As the initial step in developing a new performance indicator, several variables were analyzed, which could be used to measure a procurement activity's success in obtaining deliveries in accordance with the customer's requirements. In selecting the variables to be evaluated, the ease, cost and time required to extract information regarding the variable were considered. Additionally, a variable was not selected if procurement could not take action which would influence the variable.

2. Variables Evaluated

(a) Customer Need Data

The first variable considered was the customer's need data as stated in the Procurement Work Directive. However, the validity of such need dates are questionable. Frequently, the requiring organization will

agree to a later contractual delivery schedule because: (1) it is the best obtainable; (2) the original specified delivery date was a desired date but not an essential due date; (3) a later revision of required need date superseded and postponed the actual need date, etc. Additionally, procurement may not be able to meet the customer need date because of factors outside its control. For instance, if the minimum manufacturing lead time for an item is ten months, it would be impossible for procurement to meet a five month required due date. In view of the foregoing, this variable was not selected.

(b) Original Contract Delivery Schedule

The original contract delivery schedule should represent the best achievable delivery schedule the procurement directorate was able to achieve considering factors such as: (1) Procurement Administrative Lead Time (PALT); (2) Customer need date; (3) minimum manufacturing lead time; (4) availability of additional resources, such as funds for overtime effort, required to accel effort, etc. For example, procurement personnel may be able to improve contract deliveries to minimize the extent of the delinquency or even meet the customer need date by: (1) reducing PALT by negotiating under the authority of 10 USC 2304(a)(2) rather than formally advertising the procurement; (2) including earlier offered deliveries as a proposal evaluation factor. Thus, the ability to maintain or improve the original delivery schedule is deemed to be a good indication of procurement's ability to obtain timely deliveries.

(c) Revised Contract Delivery Schedules

Modifications are frequently issued which revise the delivery schedule. Such revisions are the result of (1) negligent Government

action, such as late furnishing of GFP; (2) negligent contractor action, such as poor production planning; (3) factors outside the control of the Government or contractor, such as a strike at a critical subcontractor's production facility; (4) a combination of the previous cited factors. Ideally, the original delivery schedule variable should be revised to reflect the portion of the delay outside of procurement's control. However, detailed analysis and the exercise of discretion are often involved in determining: (1) the degree of Government, contractor, or other external factor responsibility for the delay; (2) the extent to which the delay would have been minimized had there been timely Government action. Thus, it was decided that use of the delivery schedule performance indicator (PI) based entirely on the original contractual delivery schedule would unjustly penalize procurement directorates if the delay were beyond their control. Conversely, sole usage of the revised or current delivery schedule could result in an activity achieving a very high performance rating, based solely on issuance of delivery schedule modifications which eliminate delinquencies caused by negligent Government actions. Thus, selection of delivery schedule PI based both on the original and current contract delivery schedules was necessary.

(d) Length of the Delinquency

The length of delinquency is a variable which should be considered in assessing the procurement activity's success in obtaining timely deliveries. Assuming that the original contractual delivery schedule represents the best achievable delivery in relation to the customer's need date, it is clear that a 180 day delinquency is much more critical than a 30 day delinquency.

(e) Actual Deliveries

Finally, the last variable needed to assess activity's success in meeting the delivery objective is the date on which actual deliveries of the items were accepted by the Government.

(f) Summary

In summary, the variables which yield the best performance indicators are: (1) original delivery schedule; (2) current delivery schedule; (3) length of delinquency; (4) actual deliveries; (5) dollar value of deliveries.

3. Criteria for Index

In developing a new performance indicator the question was asked, "What criteria best measures the extent to which the Government has achieved its objective regarding timely deliveries?" Basically, it was decided that the Government has achieved its objective if (1) deliveries were made in accordance with the original delivery schedule; (2) the Government took corrective action to minimize schedule slippages; and (3) further slippages were thwarted and deliveries made in accordance with the revised delivery schedule (if any). To achieve this objective in any month, the contractor would have to deliver items equal to the number contractually required in that month plus those previously delinquent. The timely delivery index (TDI) would be:

$$TDI = \frac{\text{Amount delivered}}{\text{Amount scheduled + amount delinquent}}$$

However, this formula does not reflect the length of the delinquency and should be revised to include a delinquency factor as follows:

$$TDI_i = \frac{\text{Actual Deliveries (by period, weighted by a delinquency factor)}}{\text{Required deliveries (by period, weighted by a delinquency factor)}}$$

$$= \frac{\sum_{j=1}^{i} A_{ij} \; D_{(i-j)}}{\sum_{j=1}^{i} B_{ij} \; D_{(i-j)}}$$

where:

TDI_i = Timely Delivery Index at period i.

A_{ij} = Actual quantity delivered at period i, and used to satisfy a requirement of period j ($j \leq i$).[2]

D_k = Delinquency factor for a requirement which is k periods old (where $k = 0, 1, \ldots, i$).[3]

B_{ij} = The unfilled requirement at period i which is from period j ($j \leq i$).[4]

4. Delinquency Factor

Next a delinquency factor had to be developed. Consultations with many Government and other personnel resulted in a consensus opinion that the delinquency factor should: (1) be a continuous rather than a step function so that if used with the ALPHA computerized tracking system, which is capable of distinguishing the actual number of days delinquent, a sharp increase in the function would not result if the delinquency was, for example, 46 versus 45 days; (2) be small for periods of 30 days or less, since there is normally a time lag for the Procurement Contracting Officer to gather information

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[2]Actual deliveries are assigned to requirements by period, using the rule that older requirements are satisfied first.

[3]At period i the delinquency factor for period j is D(i-j).

[4]Once deliveries are assigned to requirements using the rule stated above, the outstanding requirements are determined by subtraction. For computation purposes only, actual deliveries are weighted (in the numerator) by the delinquency factor only if actual deliveries exceed required deliveries for the period under evaluation.

regarding the delinquency and take corrective action; (3) increase rapidly during the time spread between 30 to 150 days since the pobability that the contractual delivery schedule will be waived increases substantially throughout this period if corrective action is not taken; (4) reach a maximum at 180 days since the contract delivery schedule has most likely been waived, and further increase of the function beyond 180 days would place too much emphasis on such delinquencies and possibly distort the activity's overall performance in meeting its objective on other contracts. The delinquent factor curve depicted on Figure I was selected as best meeting the above criteria for the period from 0 to 180 days. After 180 days the delinquency factor is maintained at the constant figure of 6.0. While any of several functions could have been used, the resulting differences in the value of the timely delivery index amount basically to changes in scale. For example, an increase in the maximum value of the delinquency function would result in a corresponding decrease in both the values of the actual indices and the targets, but the same level of performance will be required for a command to achieve the corresponding target. A polynomial was finally selected because it could be easily used with the planned computer implementation. In an attempt to describe the data in a simplistic manner that would meet the above criteria, several curves were tried to approximate the data distrubution.

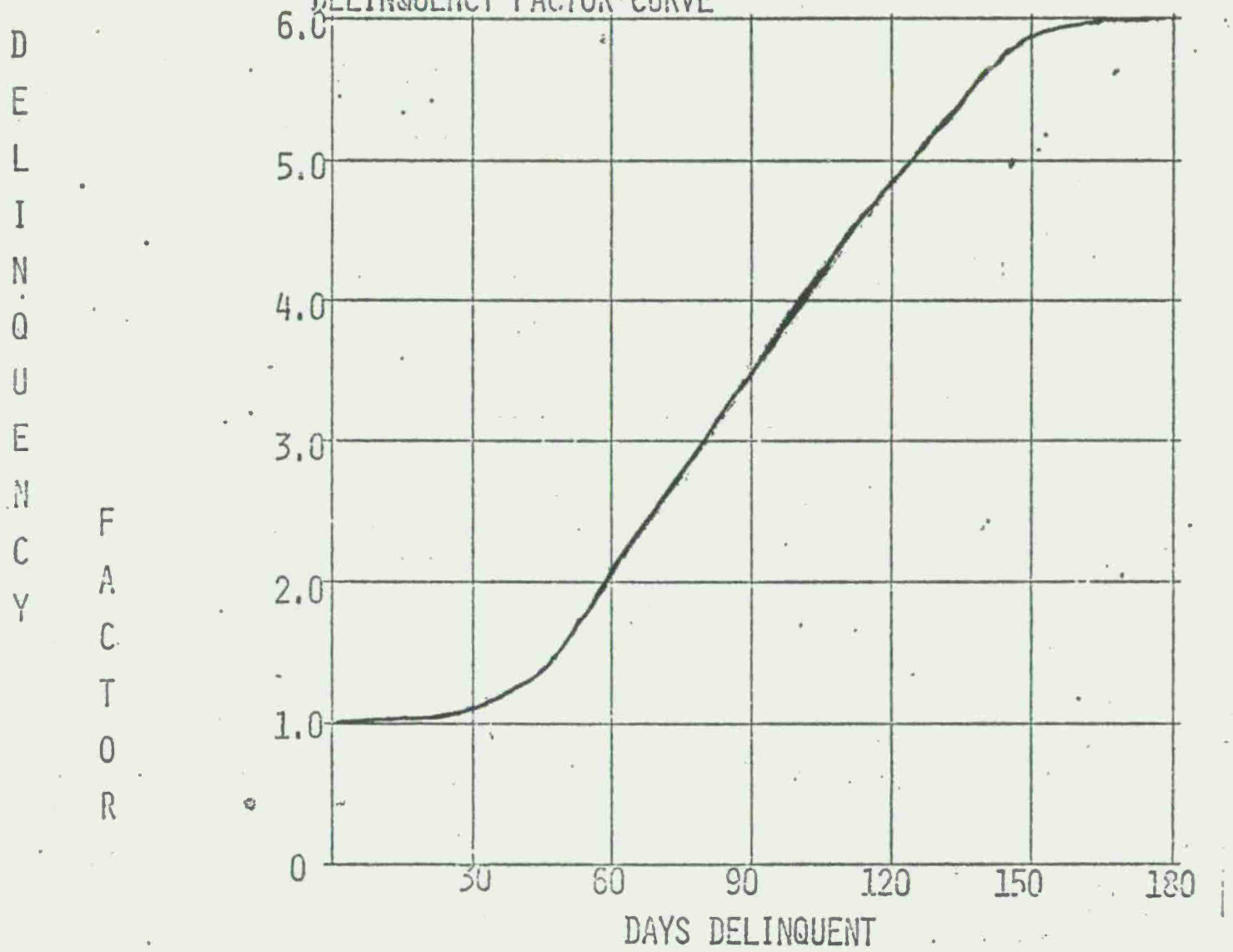
D. COMPARISON OF PROPOSED VS CURRENT DELIVERY PERFORMANCE INDICATORS

1. Individual Contracts

A numerical example will show how the current performance indicator (Delinquency Rate) can appear to be improving even while the contractor is falling further behind schedule. The example also will illustrate the calculation of the revised indicator (Timely Delivery Index) and will show how it more

FIGURE 1

DELINQUENCY FACTOR CURVE



$Y = 1.0 - .01389X + .000687X^2 - .00000253X^3$ (DEFINED AS 6.0 FOR $X > 180$ DAYS AND 1.0 FOR $X < 0$)

WHERE: X = NUMBER OF PERIODS = DAYS/30

accurately reflects the contractor's slippage. Table III, Examples of Proposed Performance Indicators Compared to Delinquency Rate, uses the same hypothetical delivery data of Table I. The contractor started making deliveries one period late and then fell further behind in the subsequent periods. The Delinquency Rate begins at 100% (the least favorable score) and then appears to improve each period. Furthermore, even while the contractor slips from 10 units behind (in periods one and two) to 13 units behind (in period five),the delinquency rate improves from .50 to .26 for these periods. The TDI, in contrast begins at 0 (the least favorable score), gives credit for the deliveries in period two, and then drops from .48 to .35 in periods two through five, accurately reflecting the fact that the contractor is falling further behind schedule. This example shows how the new performance indicator gives managers better information on a contractor's performance than the Army's current indicator.

Attention is called to the computation of the numerator in Table III. It is noted that for periods 2, 3, and 4 no delinquency factor is applied to the quantity delivered since this quantity did not exceed the required quantity. In period 6, however, the delinquency factor was applied to the excess three units delivered based on the rule of applying excess units against the most delinquent units (i.e., the delinquency factor for two periods or 2.1). Thus, an activity will receive a bonus (equivalent to the delinquency factor) in the computation of the numerator of the TDI if its corrective action reduces the extent of the delinquency.

If the cumulative actual deliveries exceed cumulative required deliveries, the TDI would be computed as follows:

PERIOD	1	2	3
Required	20	20	20
Actual	30	15	10
Surplus	10	5	(5)
TDI	1.5	1.25	.75

TABLE III

EXAMPLES OF PROPOSED PERFORMANCE INDICATOR COMPARED TO DELINQUENCY RATE

PERIOD / DELIVERIES	1	2	3	4	5	6	7	
REQUIRED	10	10	10	10	10	5		
ACTUAL	0	10	9	9	9	8	10	
CUMULATE REQ	10	20	30	40	50	55	55	
CUMULATIVE ACTUAL	0	10	19	28	37	45	55	
DELINQUENT	10	10	11	12	13	10	0	(Period 2-5) getting worse
TDI	0	.48	.42	.38	.35	.51	1.0	(Period 2-5) getting worse
DELINQUENCY RATE	100%	50%	36%	30%	26%	8%	0%	(Period 2-5) improving

$$\text{TDI} = \frac{\text{Actual Deliveries (by period, weighted by a delinquency factor)}}{\text{Required Deliveries (by period, weighted by a delinquency factor)}}$$

$$\text{TDI}_2 = \frac{(10)}{10(1.1) + (10)} = \frac{10}{21} = .48$$

$$\text{TDI}_4 = \frac{9}{(1)(2.1) + (10)(1.0)) + 10} = \frac{9}{23.1} = .39$$

$$\text{TDI}_3 = \frac{9}{(10)(1.1) + 10} = \frac{9}{21} = .43$$

$$\text{TDI}_6 = \frac{5 + 3\ (2.1)}{3(2.1) + 10\ (1.1) + 5} = \frac{11.3}{22.3} = .51$$

*Delinquency factors: For 1 period delinquent use penalty factor of 1.1; for 2 periods delinquent use penalty factor of 2.1 (See Table III).

*- (See Figure I)

$TDI_1 = \frac{30}{20} = 1.5$ $TDI_2 = \frac{15 + 10}{20} = 1.25$ $TDI_3 = \frac{10 + 5}{20} = .75$

As is seen above excess units are carried as surplus and used to satisfy the next period's deliveries.

2. Aggregate TDI for Several Items

Computation of the aggregate TDI for an activity is derived by summing the individual numerators and denominators for the TDI and dividing the totals. For instance, assume the TDI's for a command's four contracts are as follows:

Contract	TDI	Unit Price	Numerator	Denominator	Aggregate TDI
1	10/20	$10	$100	$200	
2	20/30	$12	$240	$360	
3	30/40	$12	$360	$480	
4	22/40	$14	$308	$560	
TOTAL			$1008	$1600	.63

Monthly changes in the aggregate TDI reveal overall favorable or unfavorable trends in meeting the timely delivery objectives.

E. ESTABLISHMENT OF MANAGEMENT OBJECTIVES

1. Common Basis of Measurement

For the purpose of developing an overall management objective for an activity based on the timely delivery index, it is necessary to establish a common basis of measurement.

a. Several Techniques Rejected

One possible technique would be to compute the average of the performance indicator for all items under contract requiring a delivery. This technique tends to give too much weight in the overall average to smaller dollar value items or to situations involving extremely good or bad deliveries.

On the other hand, if the actual dollar value of deliveries is used as the common measure, then contracts with larger dollar value items will carry too much weight. This may give misleading information regarding a command's success in meeting its objective since delinquent delivery of a $10 part, being procured as GFE, may be more critical than delinquent deliveries of $5,000 trucks. To illustrate the possible biases noted above, assume that a command has three items under contract and the following required and actual deliveries for the months being measured.

	Item			
Delivery	1	2	3	Cumulative
Required	500,000	10,000	10,000	520,000
Actual	500,000			500,000
TDI	1.0	.0	.0	.96

If the individual TDI's of the three contracts were averaged, an overall average rating of 33.3% would be obtained; thus giving the small dollar value items substantial weight in the overall ratings. However, if the dollar value of actual and required deliveries were used, it is seen that a misleading high rate (.96) would be obtained because of the higher dollar value items being delivered. Thus, neither of these approaches generate satisfactory data on which to establish an objective.

b. Techniques Selected

One possible objective, which will eliminate the biases noted in the previous considered techniques, is that a predetermined percentage of items under contracts (with required past or current schedule deliveries) should achieve a specified minimum timely delivery index. However, such an objective

would only be valid if items with equally critical delivery schedules are evenly spread over small and large dollar value items. This assumption is valid for the sample data examined in this study, since all items meet the criteria necessary to be classified as an intensively managed item. AMCR 5-7 provides that items selected for intensive management will undergo continuous surveillance of contract actions as required of the contractor and Government, the completion of which are essential to satisfactory contract performance and timely delivery of material in accordance with the contract delivery of all intensively managed items is considered to be critical. Hence, the objectives and targets developed in this study are considered valid for such items.

However, use of the above measurement technique by itself doesn't reflect overall improvement or deterioration in meeting the objective of obtaining timely deliveries. For example, suppose a command has five items under contract and achieved the following performance in two months:

PERFORMANCE INDICATOR

Actual ÷ Required Deliveries

ITEM	MONTH A	MONTH B
1	1.0	.9
2	1.0	.85
3	1.0	.8
4	.7	.4
5	.75	.25

If the objective were that 60% of the contracts should have a performance indication of .80 or better, this activity would achieve its objective in both months. However, actual performance has deteriorated severely in the second month. So there is a need for an overall aggregate objective to reflect such changes in actual performance. To accomplish this, a second objective should be established based on actual versus required dollar value of deliveries. As previously noted, this indicator is biased toward higher dollar items. However, changes in this indicator will alert management to improvements or deterioration in meeting its overall objectives.

2. Analysis of Performance Data

a. Obtaining Data

Actual delivery performance information was extracted form AMCRP-109, Status Report of Delinquent Deliveries - Production Schedules, for intensively managed items during the period from October 1975 to March 1976. This report includes the currently required contract delivery schedule and actual deliveries. However, the initial command forecast of deliveries is recorded on this report rather than the original contract delivery schedule. Although initial command forecasts are made subsequent to the award of the contract, they are made prior to initial production deliveries based on the activity's analysis of the contractor's production plan. While it is recognized that there may be some differences between the original contract delivery schedule and the initial command forecast, it is concluded that they would be similar or identical on the majority of contracts. Thus, the targets derived from using the initial command forecasts should be a reasonable approximation of the targets based on original delivery schedules.

Additionally, if the proposed performance indicators are implemented, the AMCRP-109 report should be modified to include the original delivery schedule, possibly by replacing the initial command forecasts.

b. Analysis of Data

The detailed calculations to compute the timely delivery indices had to be performed on a computer because of the great number of complex calculations required. An additional benefit of a computer program was that it offered an opportunity to test and verify different possible procedures to compute the timely delivery index. According to ALMSA, the present ALPHA system can be made to automatically calculate the new timely delivery index using a program similar to the one used by APRO. A formal system change request would be required to accomplish this change and would require a mininum 12 months to implement. Thus, it may be more practicable to design a subsystem in connection with the automation of the AMCRP-109 report that could be used for all items. Development of such a subsystem should be coordinated with the staff at DARCOM (DMIS). Such a system would likely be implemented through the HQ MIS system employing an additional file and analysis routine at one of the Standard Data Banks, probably at Letterkenny. This would provide the advantage of ready access through the existing query capability of the operational MARS-III System.

c. Development of Targets

Table IV,"Analysis of TDI's for Individual Items", lists the percentage of intensively managed items exceeding a specified TDI based on both the original and revised delivery schedules for each MSC during the period from January to March 1976. Table V , "Analysis of Aggregate TDI", lists aggregate TDI's for the various MSC's during the same time period.

TABLE IV

ANALYSIS OF TDI's FOR INDIVIDUAL ITEMS

PERCENT OF INTENSIVELY MANAGED ITEMS EXCEEDING TDI OF .8 BASED ON ORIGINAL SCHEDULE

	JAN 76			FEB 76			MAR 76			TARGET		
	Exceeding .5	Total Items	Percent	Exceeding .5	Total Items	Percent	Exceeding .5	Total Items	Percent	Exceeding .5	Total Items	Percent
MSC A	9	18	50%	9	19	47%	9	19	47%	11	19	58%
MSC B	5	6	83%	4	6	67%	4	5	80%	4	5	80%
MSC C	21	41	51%	21	42	50%	18	40	45%	22	41	54%
MSC D	14	19	74%	12	20	60%	10	19	53%	12	20	60%
MSC E	17	33	52%	15	31	48%	12	28	43%	15	29	52%
MSC F	17	46	37%	18	45	40%	21	46	46%	23	46	50%
AGG (DARCOM)	83	163	51%	79	163	48%	74	157	47%	87	160	54%*

PERCENT OF INTENSIVELY MANAGED ITEMS EXCEEDING TDI OF .8 BASED ON REVISED SCHEDULE

MSC A	13	19	68%	10	19	53%	10	18	56%	12	19	63%
MSC B	4	5	80%	4	5	80%	4	5	80%	4	5	80%
MSC C	22	39	56%	23	41	56%	22	40	55%	25	41	61%
MSC D	11	19	58%	12	20	60%	11	19	58%	13	20	65%
MSC E	22	31	70%	20	30	67%	15	25	60%	21	29	72%
MSC F	23	38	61%	27	38	71%	28	41	68%	33	46	72%
AGG (DARCOM)	95	151	63%	96	153	63%	90	148	61%	108	160	67%*

* DARCOM target only valid if ratio of items in MSC remains constant.

TABLE V

ANALYSIS AGGREGATE TDI'S

AGGREGATE TDI'S BASED ON ORIGINAL DELIVERY SCHEDULES

	JAN 76	FEB 76	MAR 76	TARGET
MSC A	.03	.02	.02	.25
MSC B	.71	.76	.75	.80
MSC C	.19	.23	.19	.25
MSC D	1.00	.69	.71	.80
MSC E	.19	.19	.21	.25
MSC F	.21	.19	.20	.25
AGG (DARCOM)	.21	.19	.20	.30
AGGREGATE TDI BASED ON REVISED DELIVERY SCHEDULES				
MSC A	.04	.02	.03	.50
MSC B	.82	.75	.85	.85
MSC C	.36	.53	.44	.50
MSC D	.82	.54	.53	.70
MSC E	.64	.53	.49	.60
MSC F	1.87	1.48	1.25	.90
AGG (DARCOM)	.50	.41	.38	.60

Proposed targets were developed for each of the MSC's based on analysis of the actual performance data both through computer evaluation and by subjective analysis. For example, MSC-A aggregate TDI's based on both the original and revised delivery schedule were very low. Analysis of the data revealed that a few very delinquent contracts were causing the low TDI's. A computer simulation was undertaken of the aggregate TDI's achievable by: (1) modifying the delivery schedules to eliminate the delinquencies of the two most delinquent items; (2) assuming contractor would be able to meet current command forecasts of deliveries as stated on the AMCRP-109 report, for the next three periods. The data revealed:

AGGREGATE TDI'S FOR MSC-A

	FUTURE PERIOD		
	1	2	3
Original Schedule	.12	.11	.13
Revised Schedule	.35	.62	.79

As can be seen on Table V, the proposed target aggregate TDI for MSC-A are .25 and .50 based on an original and revised delivery schedule respectively. Although these targets are considerably higher than actual performance during the period from Jan - Mar 76, the above calculations show these targets to be reasonable if those few contracts are corrected.

A review of the proposed target aggregate TDI's based on original delivery schedules reveals very low targets. For instance, the targets are .25 for four MSC's and .30 for another MSC. This reveals that the customer is not getting his material very often in accordance with the original delivery

schedule. As previously mentioned, a portion of the delivery delay was probably caused by: (1) contractor fault; (2) Government fault; (3) factors beyond the control of both parties. Considering both the low actual performance indices plus the fact the PCO cannot control some of the delay, it was decided that targets based on original delivery schedules should not be implemented. Such targets could have a demoralizing impact on an activity with low performance target. However, comparison of the aggregate TDI's based on original and revised delivery schedules in Table V, verified the need to monitor the former. For instance, MSC-F has TDI's exceeding 1.00 based on revised original delivery schedules, thus indicating good delivery performance. However, the aggregate TDI's are approximately .20 based on original delivery schedules, thus revealing that they are not meeting their original delivery schedules, which are probably most reflective of the customer need date. Thus, MSC-F's apparent good performance record based on the revised delivery schedule was partially achieved through the issuance of contract modifications which modified delivery schedules.

The DARCOM targets proposed in Table IV and V are a cumulative weighted average of all the MSC's. This target would be subject to revision if the mix within the various MSC's changes.

d. Proposed Targets

Based on the previous analysis, the following proposed targets were established:

(1) Individual Items

(a) Based on the revised delivery schedule the DARCOM TDI for all intensively managed items with required deliveries shall be .8 or higher for 67% of the individual items.

(b) Based on the revised delivery schedule, the TDI for each of the following MSC's for all intensively managed items with required deliveries shall be .8 or higher for the noted percentage of individual items

MSC	%
MSC A	63
MSC B	80
MSC C	61
MSC D	65
MSC E	72
MSC F	72

(2) Aggregate for All Items

(a) Based on the revised delivery schedule, the DARCOM TDI for all intensively managed items with required deliveries shall be .6 or higher based on dollar value of all items.

(b) Based on revised delivery schedule, the TDI, for each of the following MSC's, for all intensively managed items with required deliveries shall be the noted percentage or higher based on dollar value of all items.

MSC	%
MSC A	50
MSC B	85
MSC C	50
MSC D	70
MSC E	60
MSC F	90

F. EVALUATION OF TDI PERFORMANCE DATA

1. Reports

Two proposed reports have been developed to aid the manager analyzing actual performance data. The first report is shown on Table VI TDI Data for XCOM. This report allows the manager to track for a 12 month period both the aggregate TDI's and the percentage of individual items being procured exceeding a specified percentage based on both original and revised delivery schedules. As will be shown later, trends spotted in this report may alert the manager of the need for action to thwart pending or actual delinquencies.

Table VII "Timely Delivery Report", shows the second report to be used. This report will give specific information regarding contract delinquencies, such as: (1) the contract number; (2) extent of the delinquency; (3) reason for the delinquency. Additionally, information regarding forecast or future delinquencies would be listed on this report. Frequently, a Government official, such as the ACO, will become aware of an impending delinquency prior to the actual contract delivery dates. By including such information on this report, the PCO and procurement manager will be alerted early to the need for remedial action. It is important to take early corrective action in order to eliminate or minimize the extent of potential delinquency.

2. Hypothetical Evaluation

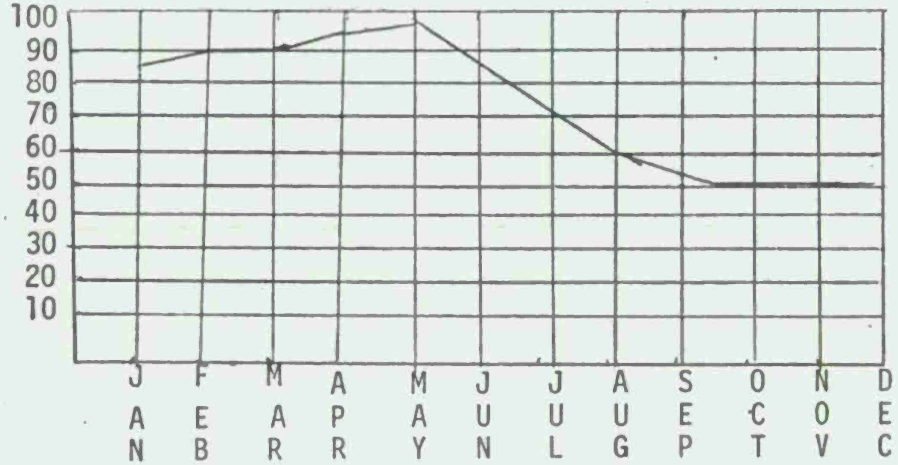
A hypothetical case will be presented to show how the new performance indicator can aid a manager. The management charts depicted in Table VI will be used to illustrate the example. By reviewing these charts, the manager could have detected the following possible trends during the year.

TABLE VI

TDI DATA FOR XCOM

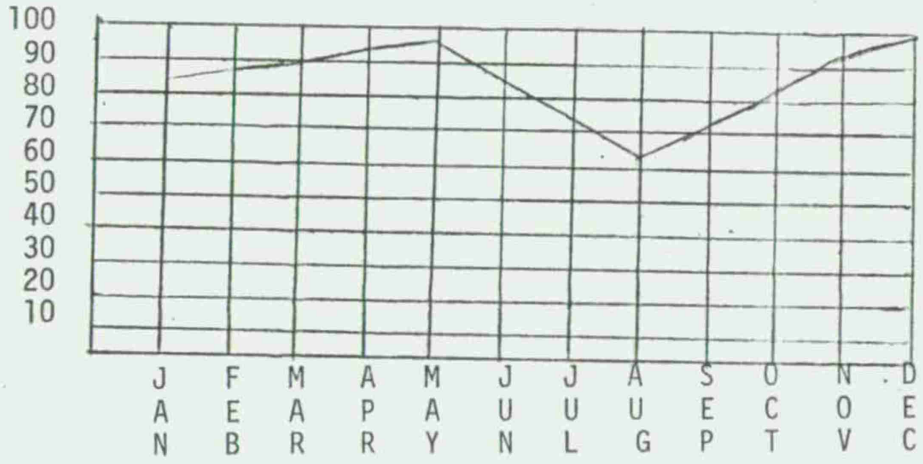
% of Items

Percentage of Items Requiring Deliveries with TDI Exceeding .6 Based on Original Contract Delivery Schedule



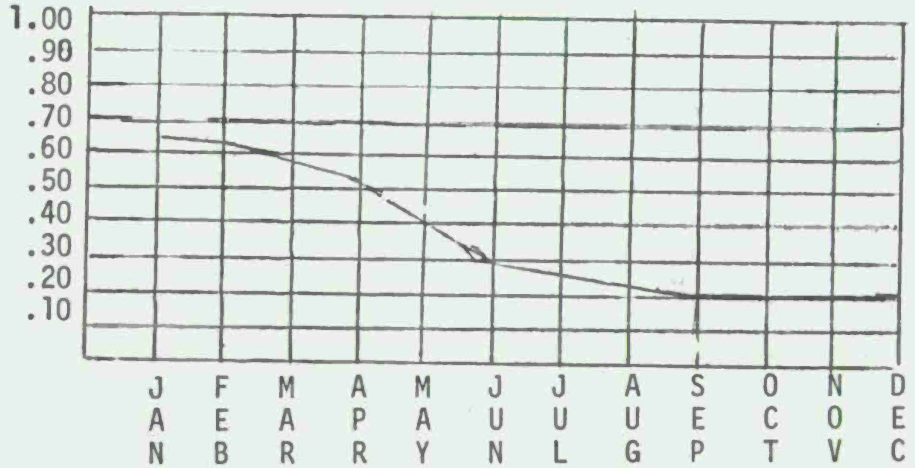
% of Items

Percentage of Items Requiring Deliveries with TDI Exceeding .8 Based on Current Contract Delivery Schedule



Aggregate TDI for All Items Requiring Deliveries Based on Original Contract Delivery Schedule

TDI



Aggregate TDI for All Items Requiring Deliveries Based on Current Contract Delivery Schedule

TDI

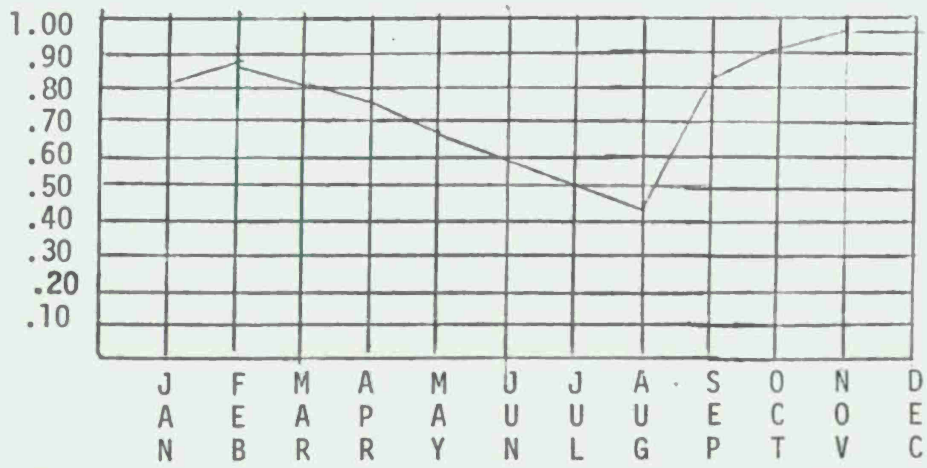


TABLE VII

TIMELY DELIVERY REPORT

COMMAND_____

REPORT PERIOD_____

A. ORIGINAL SCHEDULE

TDI (ITEM)_____

TDI ($)_____

B. CURRENT SCHEDULE

TDI (ITEM)

TDI ($)

C. DELINQUENT CONTRACT INFORMATION

D. FORECAST DELINQUENCIES

a. Jan-May. The percentage of items being procured with the TDI exceeding the predetermined figure was increasing and was above the objective. However, the decreasing aggregate TDI shows a deteriorating condition in getting timely deliveries. Further evaluation might reveal (i) a general decrease in the TDI's for most items but the TDI's for such items had not decreased below the predetermined objective figure, (ii) a sharp decrease in the TDI for a few problem items, probably those with TDI's below the predetermined figures. Thus, the decline in the aggregate TDI portends a potential problem which may warrant further investigation and possible corrective action.

b. Jun-Aug. The potential unfavorable trend noted in the Jan-Apr time period has materialized as evidenced by the downward trend of all performance indicators. Immediate corrective action is required.

c. Sep-Dec. The improvement in the indicators based on current delivery schedules; without a similar improvement based on original delivery schedules reveals (i) modifications were issued to the contract delivery schedule; (ii) corrective action employed did not rectify the delinquencies but did prevent further slippages in deliveries as noted by the leveling of the indicators based on original delivery schedules.

This is an example of how trend analysis of the timely delivery index can alert managers of the possible need for action. Specific information obtainable from the proposed "Timely Delivery Report" regarding actual or potential contract delinquencies should provide the manager with additional facts which will influence his decision. Thus, implementation of the proposed timely delivery index, including the proposed performance targets and reports, will help DARCOM meet its objective of obtaining timely deliveries in accordance with the customer need date.

CHAPTER III

FINDINGS AND RECOMMENDATIONS

A. FINDINGS

Analysis of commonly used performance indicators reveals that a manager is supplied with information regarding the percentage of items delinquent based on contract delivery schedules. Such information is useful to supply management activities in generating supply status information. However, these indicators can provide misleading information regarding a procurement activity's success in obtaining deliveries in accordance with contract delivery schedules. For example, delinquency rates which measure the percentage of the dollar value of delinquencies to cumulative required deliveries were found to: (1) be a function of previous deliveries; (2) give an individual contract an increasing impact on the overall delinquency rate as the contract advances further down its life cycle.

The five variables which give the best measurement of a procurement activity's success in obtaining deliveries in accordance with the customer's requirements are: (1) original delivery schedule; (2) current delivery schedule; (3) length of delinquency; (4) actual deliveries; (5) dollar value of deliveries. Information regarding each of these variables, except the original contract delivery schedule, is reported on the AMCRP-109, Status Report of Delinquent Deliveries - Production Deliveries.

A new performance indicator, the timely deliver index, overcomes the deficiencies of the current indicators. It includes a delinquency factor which increases with the length of the deliquency. By reducing the performance indicator for contracts with lengthy delinquencies, this delinquency factor will alert management earlier to problem contracts.

Computation of the timely delivery index requires numerous and repetitive calculations. Therefore, it is impractical to compute TDI's manually. However, the feasibility of calculating the TDI's by use of a computer program has been verified. Additionally, ALMSA has advised that they could integrate this proposed performance indicator as part of the ALPHA system. However, such a change to ALPHA would require a System Change Request and a minimum 12 month leadtime. Hence, it may be more practical to design a subsystem in connection with the automation of the AMCRP-109 report that could be used for all items. Development of such a subsystem should be coordinated with the staff at DARCOM (DMIS).

Tentative performance targets for the various MSC's and HQ DARCOM are presented in this report for intensively managed items. These targets are based on analysis of actual performance data for a six month period from Oct 75 to Mar 76. Substantial unfavorable deviations from these targets will alert managers of the need to devote additional resources to minimize the impact of potential or existing delinquencies. Similarly, substantial favorable deviations can result either from good overall performance or overly lenient delivery modifications to contracts.

Finally, proposed reports are developed with meaningful information on which to base his decisions regarding necessary action to remedy delivery problems.

B. RECOMMENDATIONS

1. The proposed performance indicator, the timely delivery index, developed in Chapter II be used to measure timely deliveries. This will require:

a. Coordination with HQ DMIS to determine the best way to

implement the proposed system.

b. Establishment of the new management reports, as described in the study (Table VI and VII).

c. Modification of the "Status Report of Delinquent Deliveries-Production Deliveries" (AMCRP-109) to show original contract delivery schedules.

d. Monitoring aggregate and individual item TDI's based on the original contract delivery schedule.

2. Establishment of performance targets based on revised delivery schedules, as developed in this study (Table IV and V) for HQ DARCOM and the MSC's.

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3. Draper, N. H. and Smith, H., Applied Regression Analysis, Wiley, 1966.

APPENDIX A

STUDY TEAM COMPOSITION

The study team consisted of the following individuals:

Harold F. Candy, Project Officer, Procurement Analyst, US Army Procurement Research Office, ALMC. BS, Pennsylvania State University, 1962. Prior to joining APRO in August 1969, Mr. Candy was employed as a Contract Specialist for seven years with the US Navy Aviation Supply Office, Philadelphia, Pennsylvania. Mr. Candy received an MS in Contract and Procurement Management at Florida Institute of Technology, Melbourne, Florida in September 1974. In addition to his research assignment Mr. Candy instructs in a graduate level procurement program at a local university.

Richard C. Brannon, Statistician, US Army Procurement Research Office, ALMC. MS, Mathematics 1967, Southern Illinois University, Carbondale, Illinois. BA, Mathematics and Statistics 1965, University of Missouri, Columbia, Missouri. Prior to his assignment to APRO, Mr. Brannon was an Operations Research Analyst with the Comptroller of the Army, Washington, DC, working on life cycle cost estimates for weapons systems. Mr. Brannon has also worked as a computer systems analyst and has taught Calculus, Analytic Geometry and Algebra at the college level.

Shirley H. Carter, BS in General Agriculture, Virginia Polytechnic Institute, 1953. MS, Agricultural Economics, Virginia Polytechnic Institute, 1957, additional graduate study, Economics and Statistics, North Carolina State College, 1958-60. Mr. Carter has been employed at the US Army Procurement Research Office, ALMC as a Computer Specialist since 1970.

Mr. Carter has worked on several projects dealing with cost growth in Government contracts, incentive contracting, services contracts, award fee provisions, economic analysis, design to cost, and mathematical models for forecasting procurement workload. Prior to joining the APRO, Mr. Carter was a Systems Analyst and Assistant Chief of the Office of Programs Management for the Semi-Automated Ground Environment Command and Control System, US Air Force. He has previous research experience at North Carolina State College and Virginia Polytechnic Institute.